White Rabbit Management and Monitoring

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Agenda

- A few words about myself
- Short overview of White Rabbit network and equipment
- Supported protocols for monitoring and management
- Command line tools

Who am I?

(In the context of White Rabbit Management and Monitoring)

- Worked at CERN for 5 years (2014-2019)
  During this time:
  - Maintainer of White Rabbit Switch software
    - Over 900 commits
    - Integrated SNMP, LLDP, Kerberos+LDAP daemons
    - Implemented WR-SWITCH-MIB
  - Key developer of WRPC software (WR node)
    - Over 500 commits
    - Developed SNMP agent
    - Developed LLDP daemon
  - Involved in the design of configuration tool for WRS at CERN
  - Supported integration of WRS and WRPC monitoring at CERN
  - Implemented White Rabbit dissector for Wireshark sniffer
- Since 2020:
  Independent White Rabbit and Embedded Systems consultant:
  - Implemented BRIDGE-MIB and Q-BRIDGE-MIB for WRS
  - Implemented VLAN support for LLDP
  - Author of MIB for IEEE 1588 (PTP) standard

Agenda

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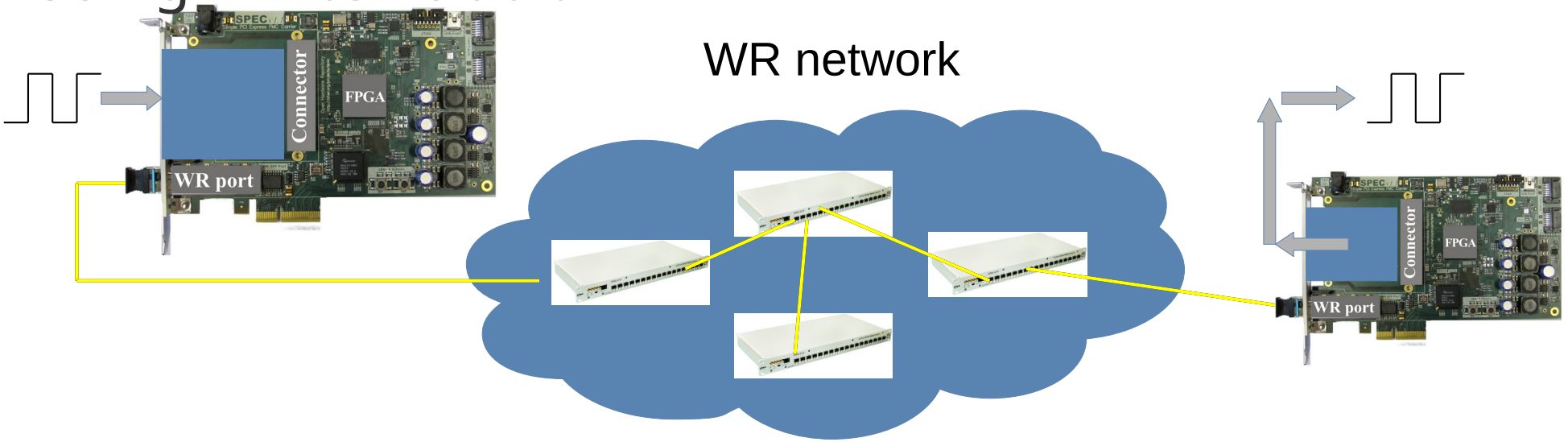
- Supported protocols for monitoring and management
- Command line tools

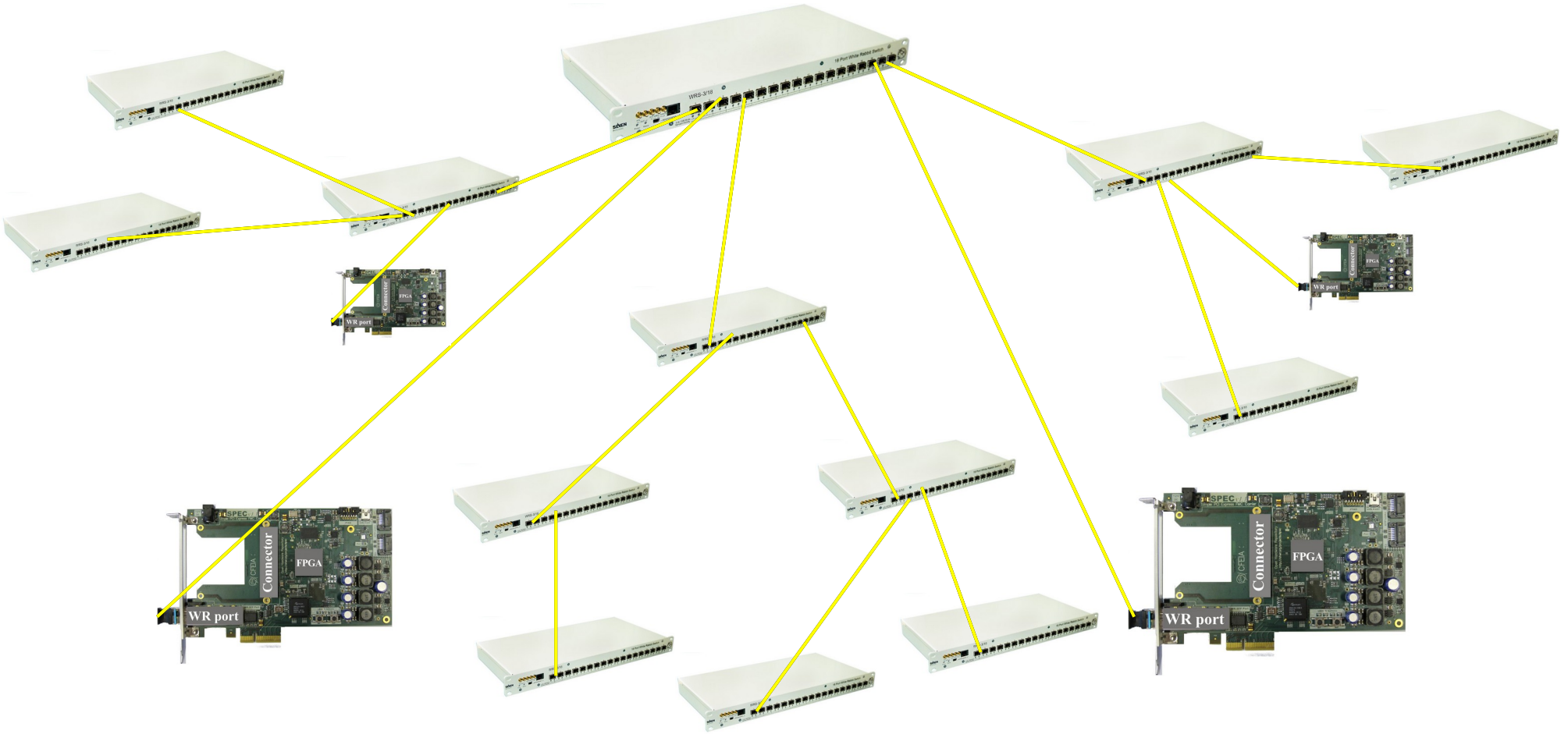
Transmission medium

- e.g. coaxial cable

- Using White Rabbit



Example White Rabbit network



- Challenging to manage big network

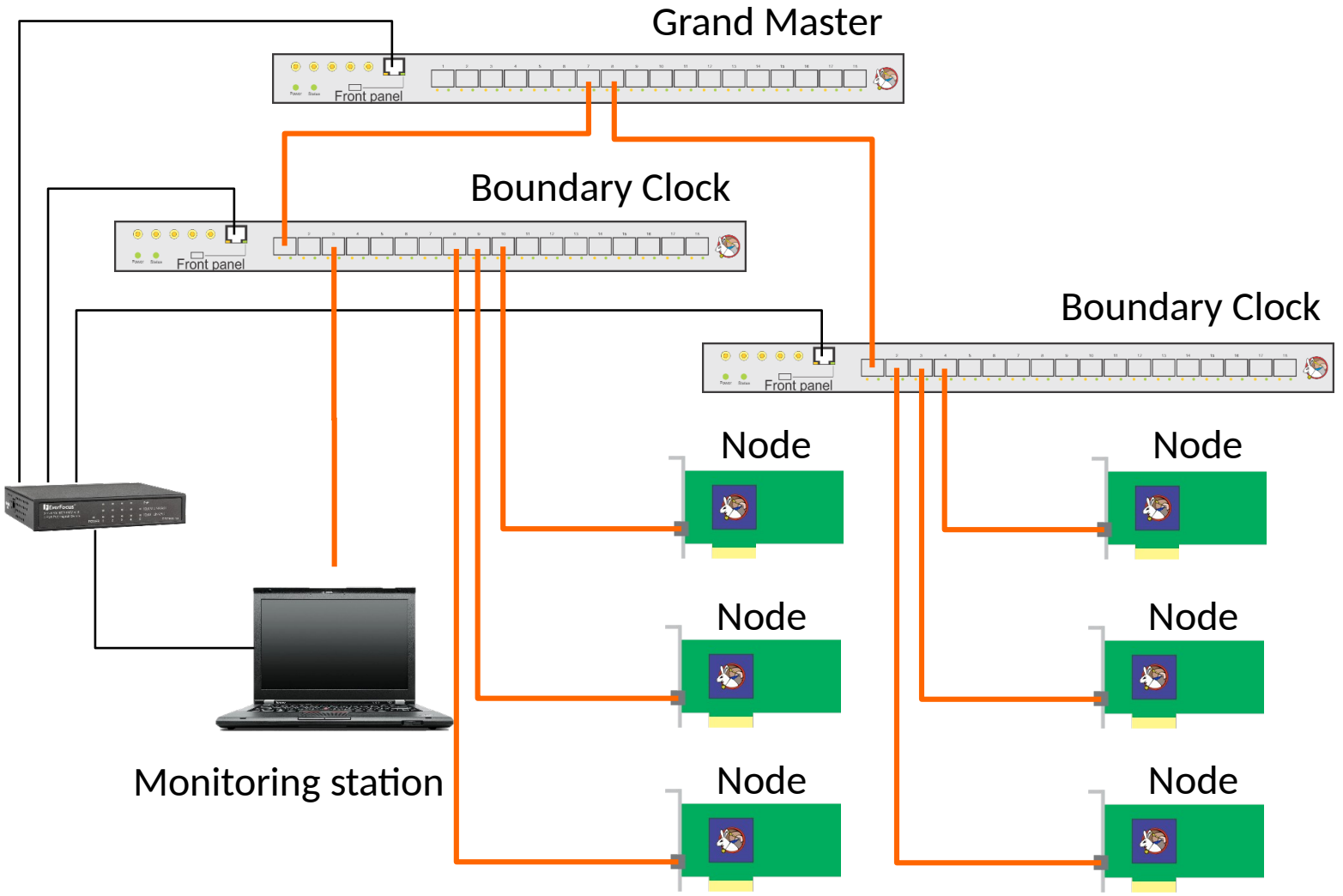
White Rabbit Switch (WRS)

- 18x 1GbE ports (SFP)
  - Supports 1Gb SFPs (fiber, copper (no WR))
  - WR supported only on some fiber SFPs
- 1x 100Mbit Management port (RJ-45)
- White Rabbit network is separated from management
  - It is possible to hack, but limited throughput (~1MBit/s)

More information about WR switch:

https://ohwr.org/project/white-rabbit/wikis/SummaryWRProjects#switch-related

Monitoring of White Rabbit network



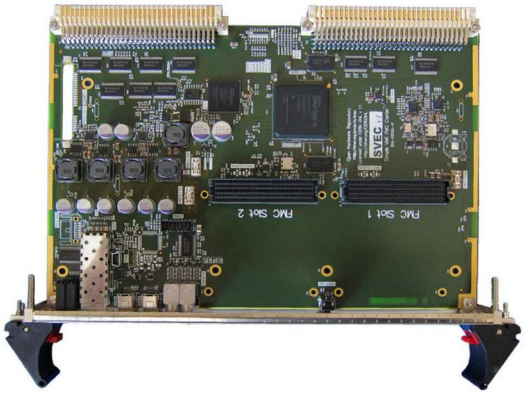
White Rabbit Node

- White Rabbit PTP Core (WRPC)
- Usually 1x 1GbE WR port
- In a host or standalone mode
- Management and Monitoring functions implemented in Soft Core CPU (LM32) in FPGA
- Very limited resources (esp. memory)
- In form of different standards:
  - PICe: SPEC
  - VME: SVEC, VFC-HD
  - CPCI: SPEXI
  - uTCA

FMC & CompactRIO

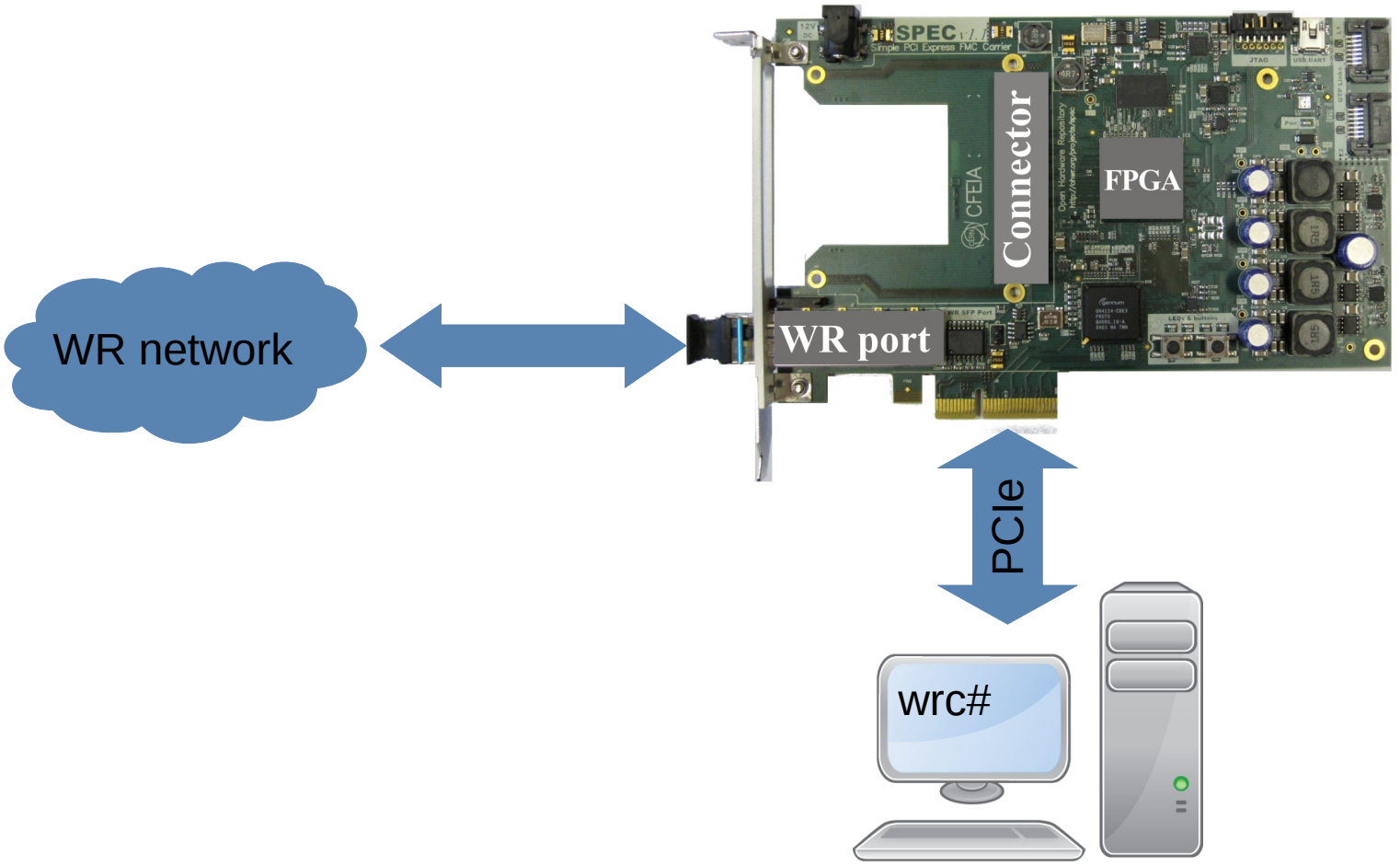
PCI Express

PXI Express



VME

WRPC: communication



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- **Supported protocols for monitoring and management**
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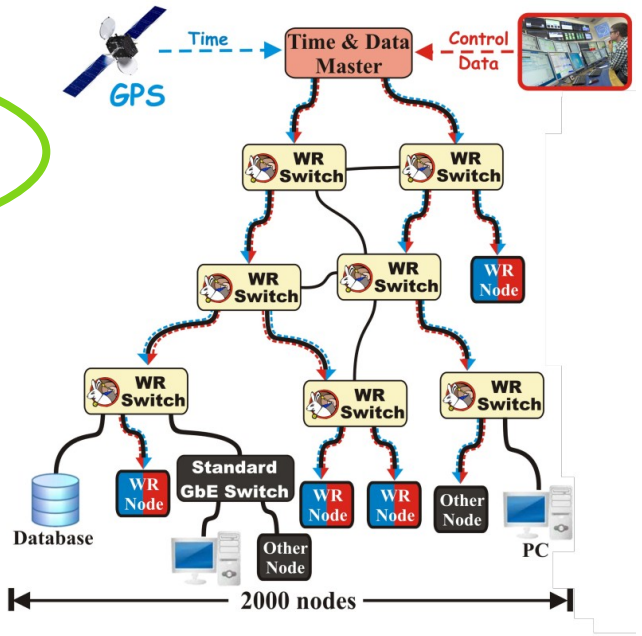
White Rabbit

What is White Rabbit?

- Initiated to renovate CERN's and GSI's accelerator timing systems
- **Based on well-established standards**
  - Ethernet (IEEE 802.3)
  - Bridged Local Area Network (IEEE 802.1Q)
  - Precision Time Protocol (IEEE 1588)
- **Extends standards** to meet new requirements and provides
  - Sub-ns synchronisation
  - Deterministic data transfer
- Initial specs: links ≤10 km & ≤2000 nodes
- **Open Source and commercially available**

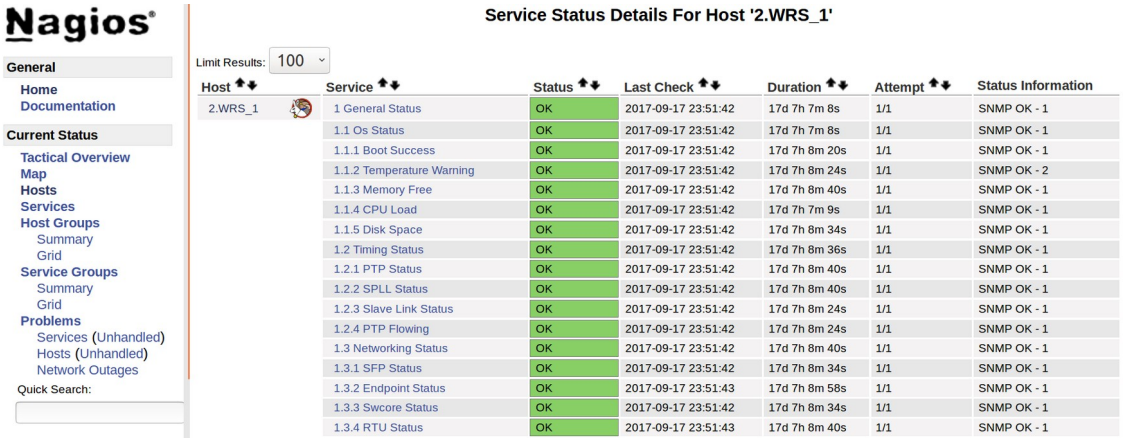


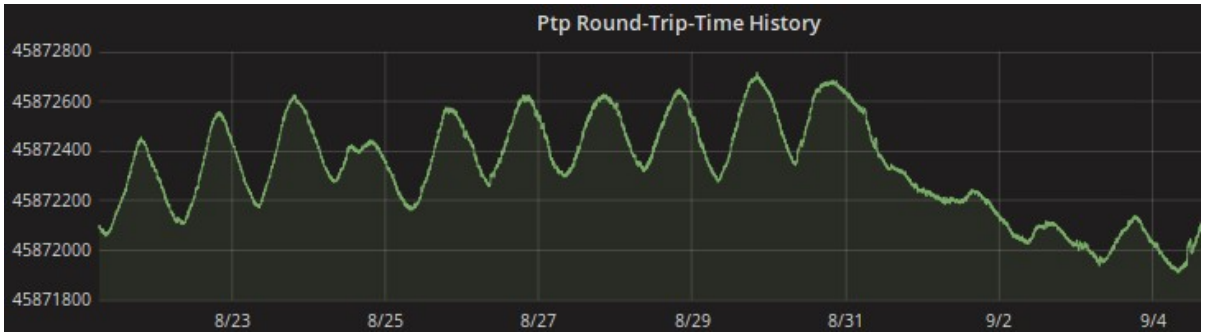
Source: https://ohwr.org/project/white-rabbit/wikis/uploads/da6d8abed6402112c5c1c0278b422299/wr_ws11_intro_2021_10.pdf

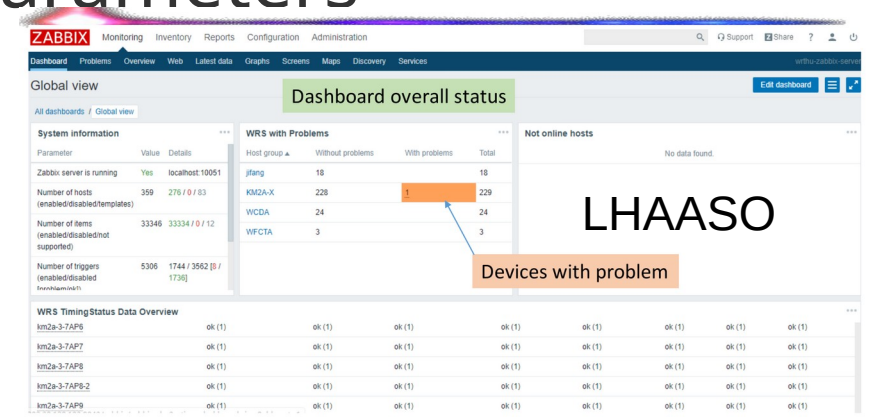
Let's use it!

Network monitoring (SNMP)

- Timing monitoring (Sync status)
- WRS: more than 300 specific parameters
- WRPC: ~70 parameters





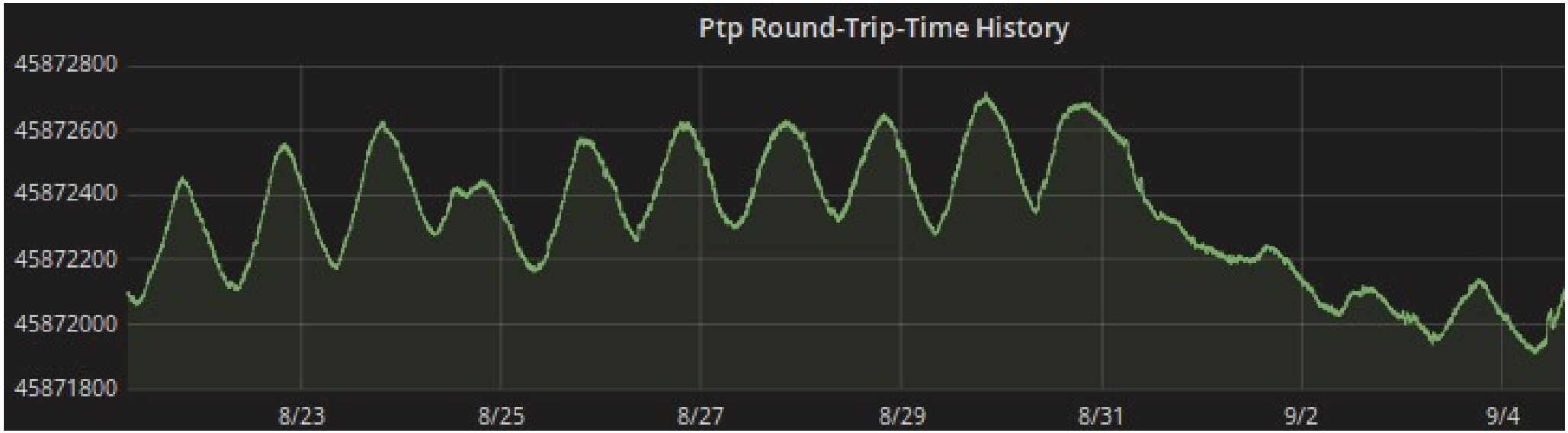


Monitor： WRS sync status, packet flow of WRS port, RTT, temperature, etc..

Source: https://ohwr.org/project/white-rabbit/wikis/uploads/ea8d8eac37a97df1cf3cb097d081b8f4/WR_at_LHAASO.pdf

Monitoring example

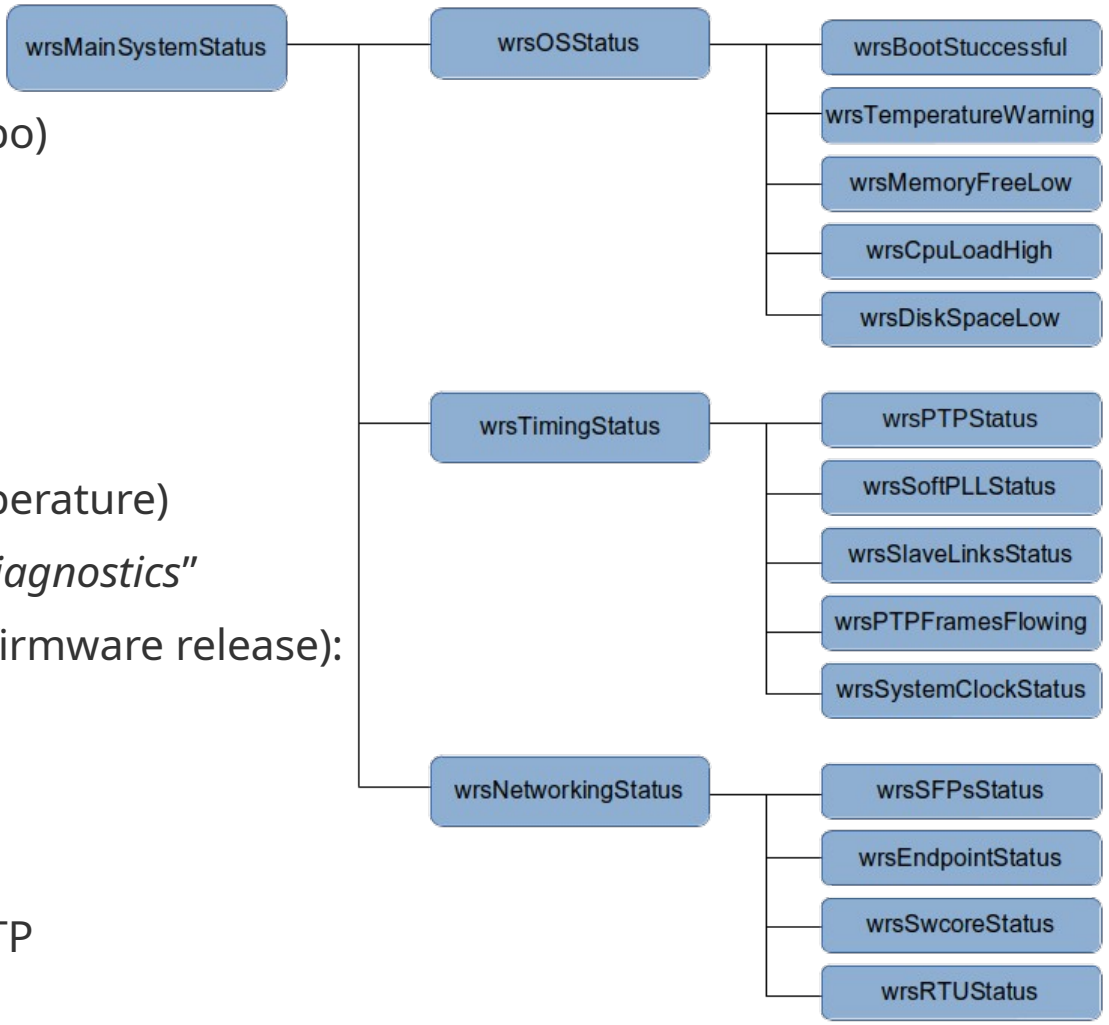
- Is the correction by White Rabbit needed?
- Link ~5km, underground
- ~400ps RTT difference between day and night
- >1ns due to the weather



WRS: SNMP

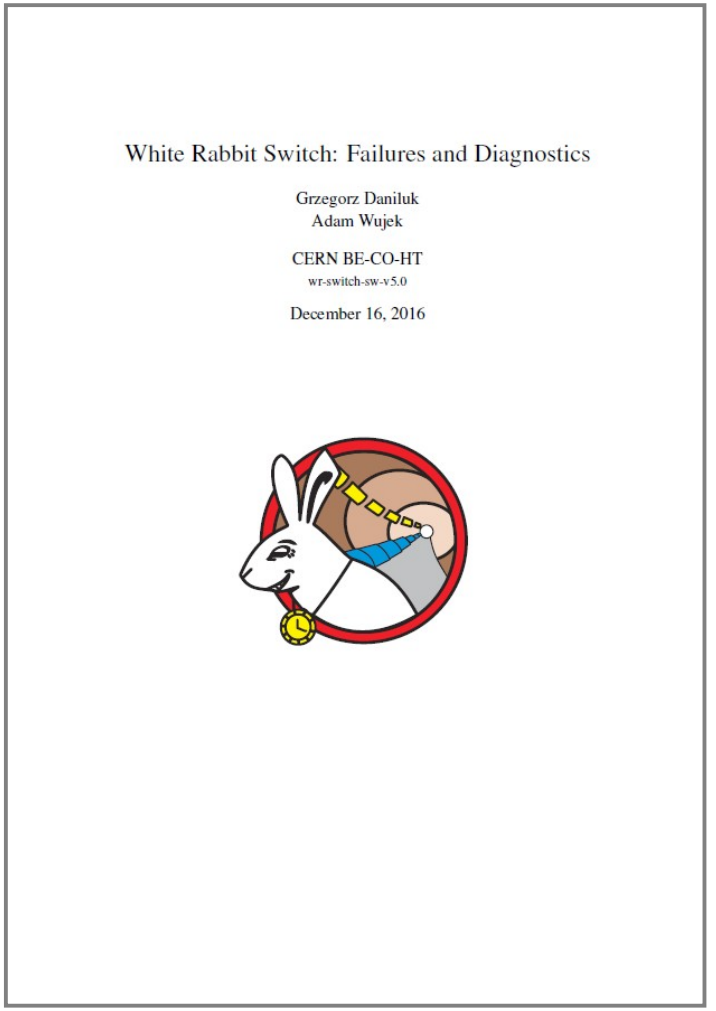
- WR-SWITCH-MIB (in wr-switch-software repo)
  - status OIDs
  - expert OIDs like:
    - Port status and configuration
    - Timing status and configuration
    - SFP monitoring (e.g. vendor, temperature)

  More in "*White Rabbit Switch: Failures and Diagnostics*"
- Standard MIBs (to be included in the next firmware release):
  - MIB-IP
  - Q-BRIDGE-MIB (VLANs)
  - BRIDGE-MIB (MAC routing tables)
  - Ongoing standardization of MIB for PTP
    - Implementation in the future
- Note: SNMP cannot be used to change the configuration of WRS



WR Switch: Failures and Diagnostics

- Document published with WR Switch firmware release
- Lists various errors reported by a switch
- Analyses problems that cause the error
- Proposes actions to mitigate problems
- Similar document exists for WRPC (node)


White Rabbit Switch: Failures and Diagnostics

Grzegorz Daniluk
Adam Wujek

CERN BE-CO-HT
wr-switch-sw-v5.0

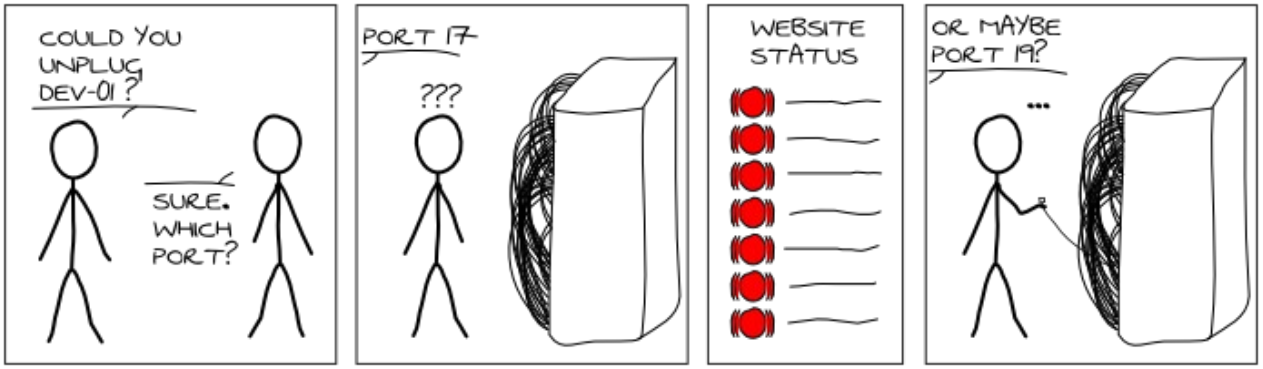
December 16, 2016

WRPC: SNMP

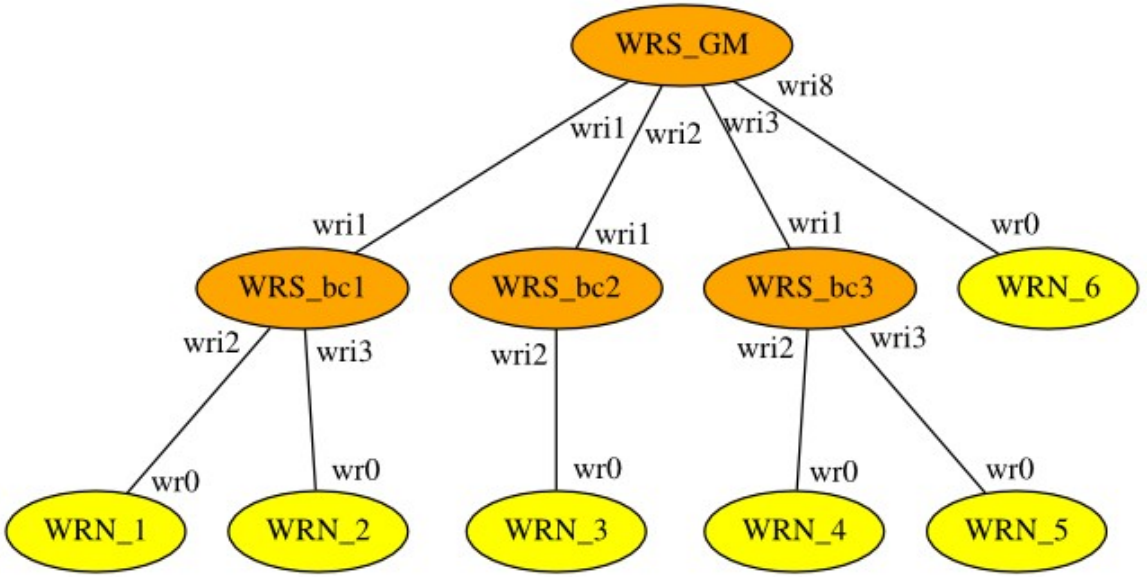
- WR-WRPC-MIB (in wrpc-sw repo)
  - No status OIDs
  - Port’s statistics
  - PTP/WR timing status and configuration
  - SFP calibration database
  - SFP monitoring (temperature, RX/TX power)
- SNMP can be used to configure some parameters:
  - SFP database
  - Init script
  - Remote shell command execution
- Not Secure! No SNMP v3

Network Topology (LLDP)

- What device is on the other side of a link?
- Supported by WR Switch and WRPC



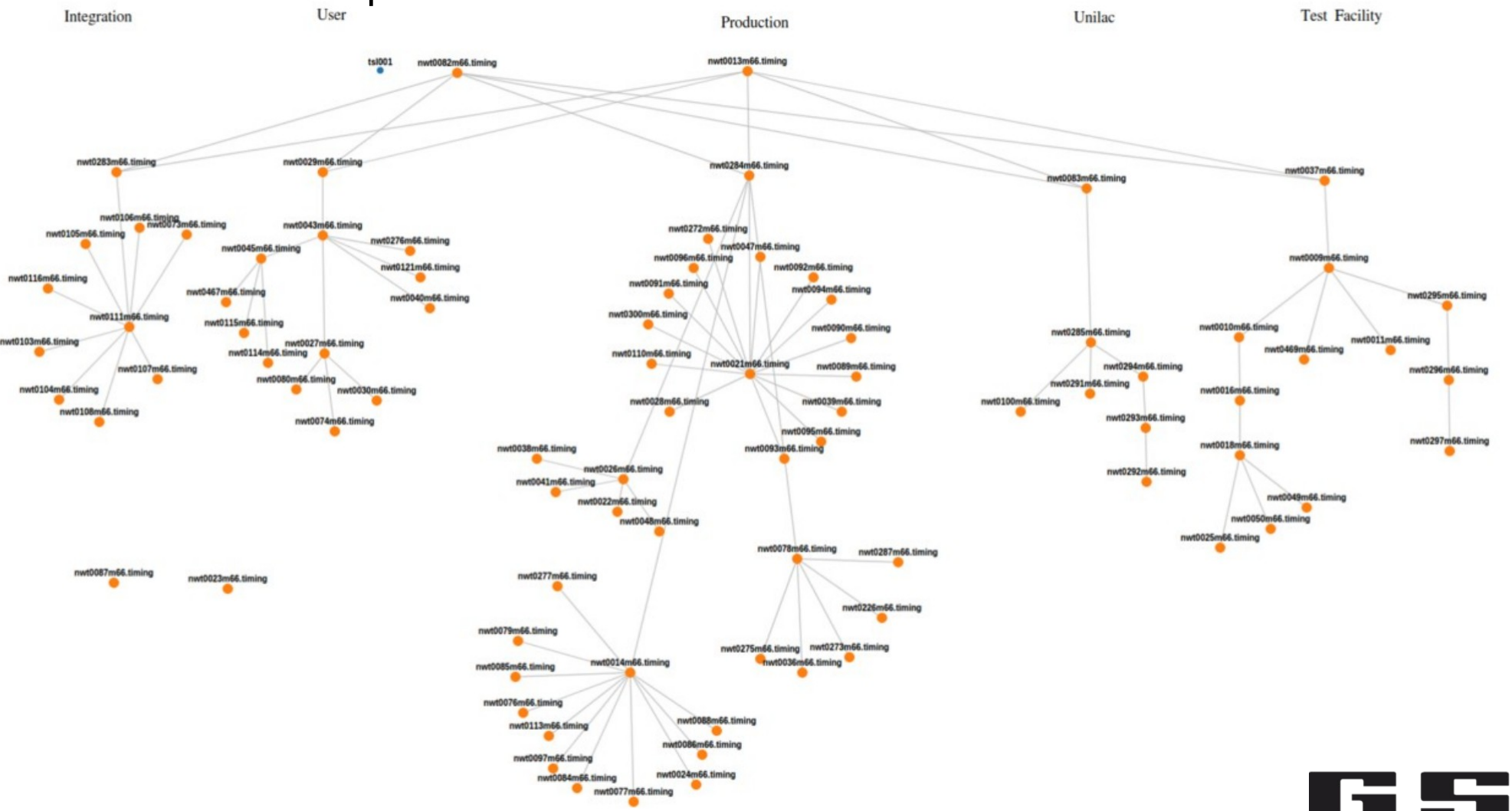
https://lldpd.github.io/media/images/why.png



Source: https://ohwr.org/project/white-rabbit/wikis/uploads/a8d91abf3b93a50065154943f2f82747/2021_wrgsi_wrWorkshop_v1.pdf

Network Topology (LLDP)

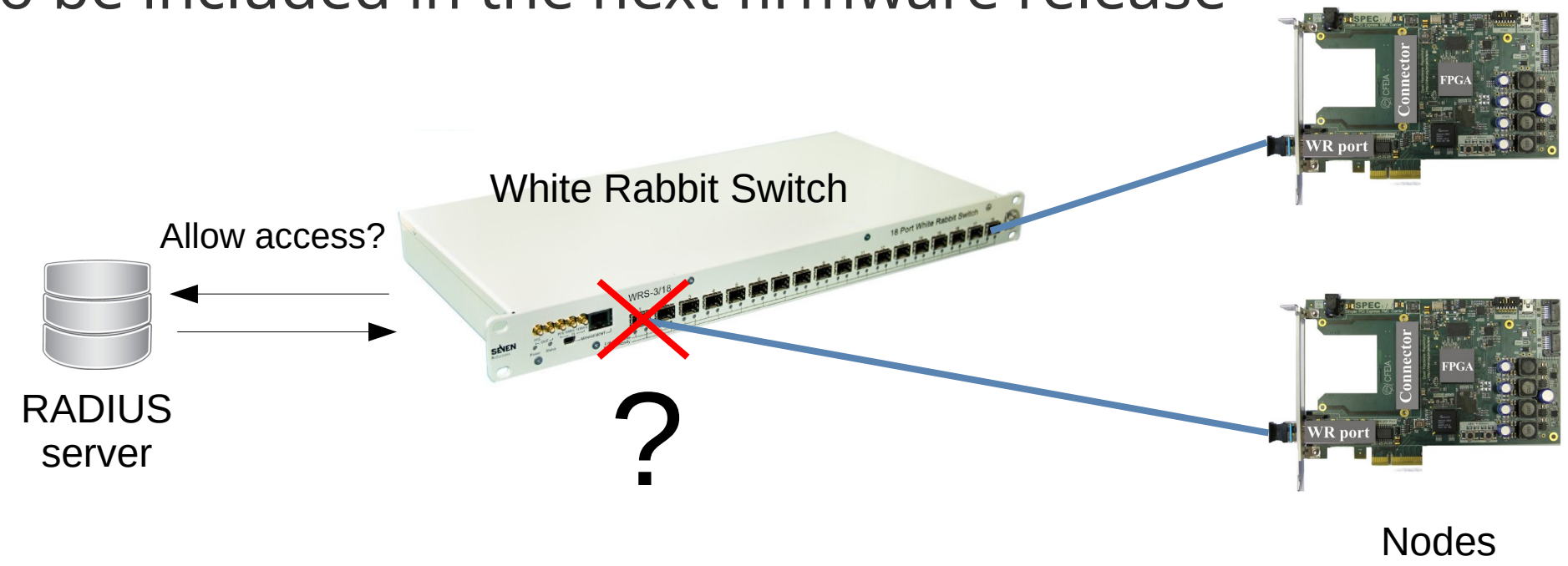
Real life example: GSI



Source: https://ohwr.org/project/white-rabbit/wikis/uploads/a8d91abf3b93a50065154943f2f82747/2021_wrgsi_wrWorkshop_v1.pdf

WRS: RADIUS

- Based on information on RADIUS server WRS can limit access to WR network
- Uses VLANs to limit access
- To be included in the next firmware release



WRS: Configuration file

Applied at startup, contains:

- Management interface's configuration
- Timing configuration (calibration values, mode)
- Remote log server address
- Log verbosity level
- VLANs configuration
- and more

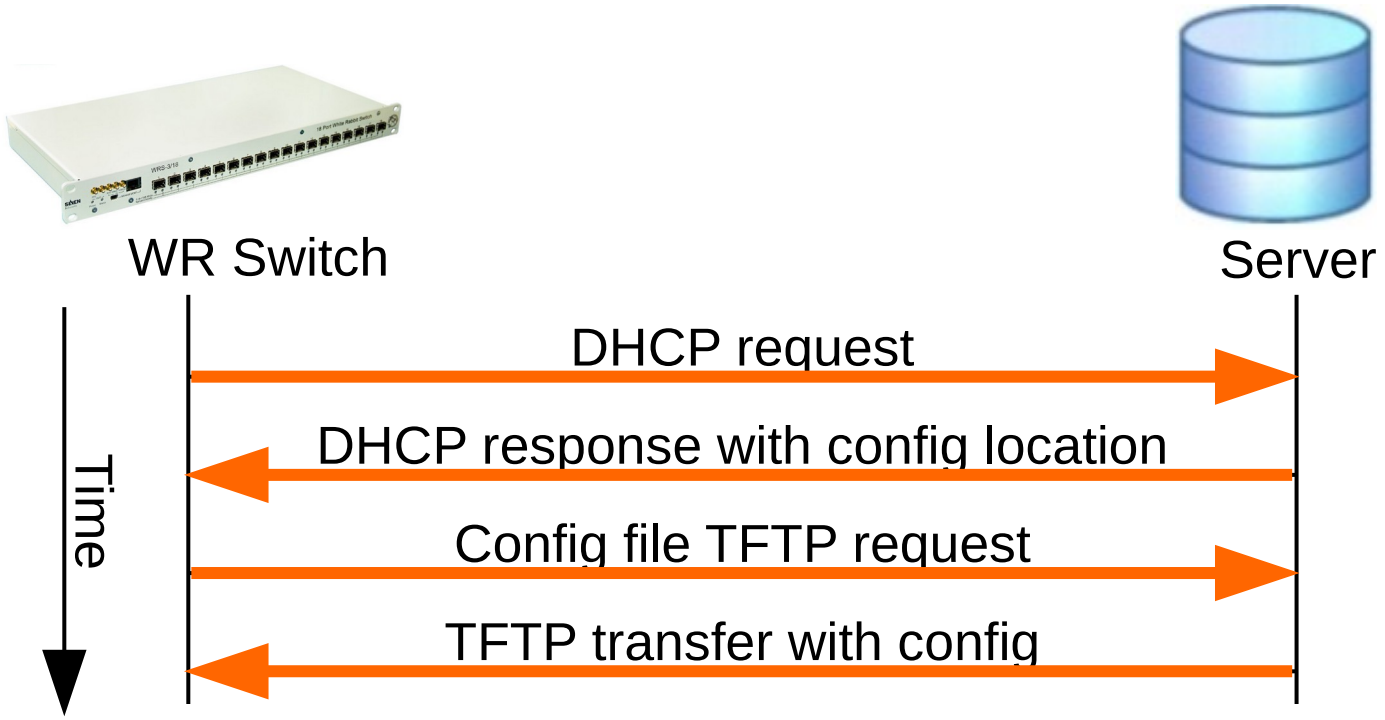
WRS: Configuration file

- Kconfig format
  - The same as used by Linux Kernel
  - {key}={value} format

```
CONFIG_ETH0_DHCP=y
# CONFIG_ETH0_DHCP_ONCE is not set
# CONFIG_ETH0_STATIC is not set
CONFIG_HOSTNAME_DHCP=y
# CONFIG_HOSTNAME_STATIC is not set
[...]
CONFIG_REMOTE_SYSLOG_SERVER="be-co-tracing"
CONFIG_REMOTE_SYSLOG_UDP=y
CONFIG_WRS_LOG_HAL="daemon.info"
CONFIG_WRS_LOG_LEVEL_HAL="0"
[...]
#
# Port Timing Configuration
#
CONFIG_PORT01_PARAMS="name=wri1,proto=raw,tx=223897,rx=226273,role=master,fiber=0"
CONFIG_PORT02_PARAMS="name=wri2,proto=raw,tx=224037,rx=226377,role=master,fiber=0"
CONFIG_PORT03_PARAMS="name=wri3,proto=raw,tx=224142,rx=226638,role=master,fiber=0"
CONFIG_PORT04_PARAMS="name=wri4,proto=raw,tx=224313,rx=226471,role=master,fiber=0"
```

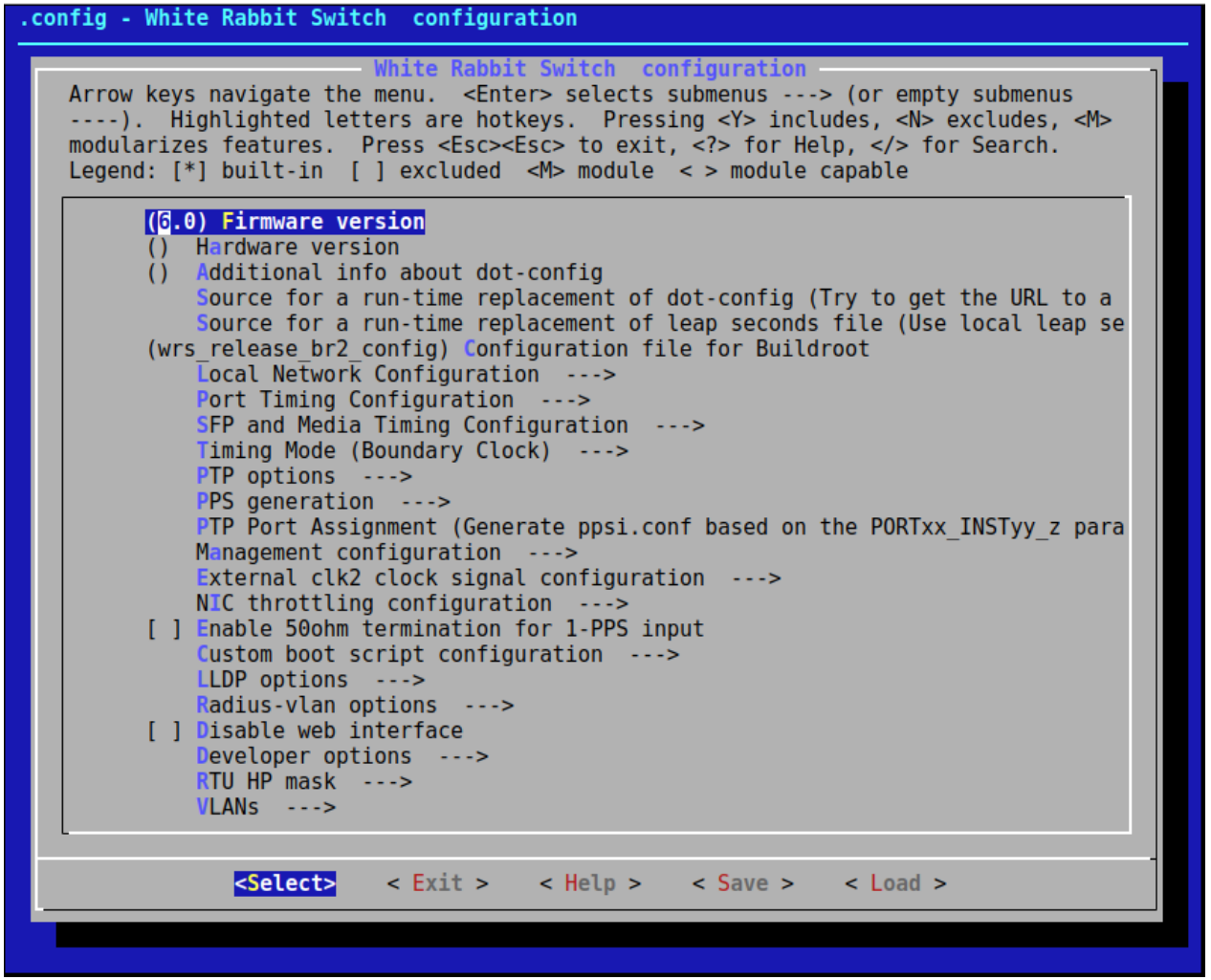
WRS: Config file handling

- Local on a switch
- Retrieved from a network at boot (via TFTP, FTP or HTTP)
- Path to a config provided in a DHCP response



WRS: Editing config file

- In text editor
- Kconfig tools (make menuconfig, make nconfig etc.)



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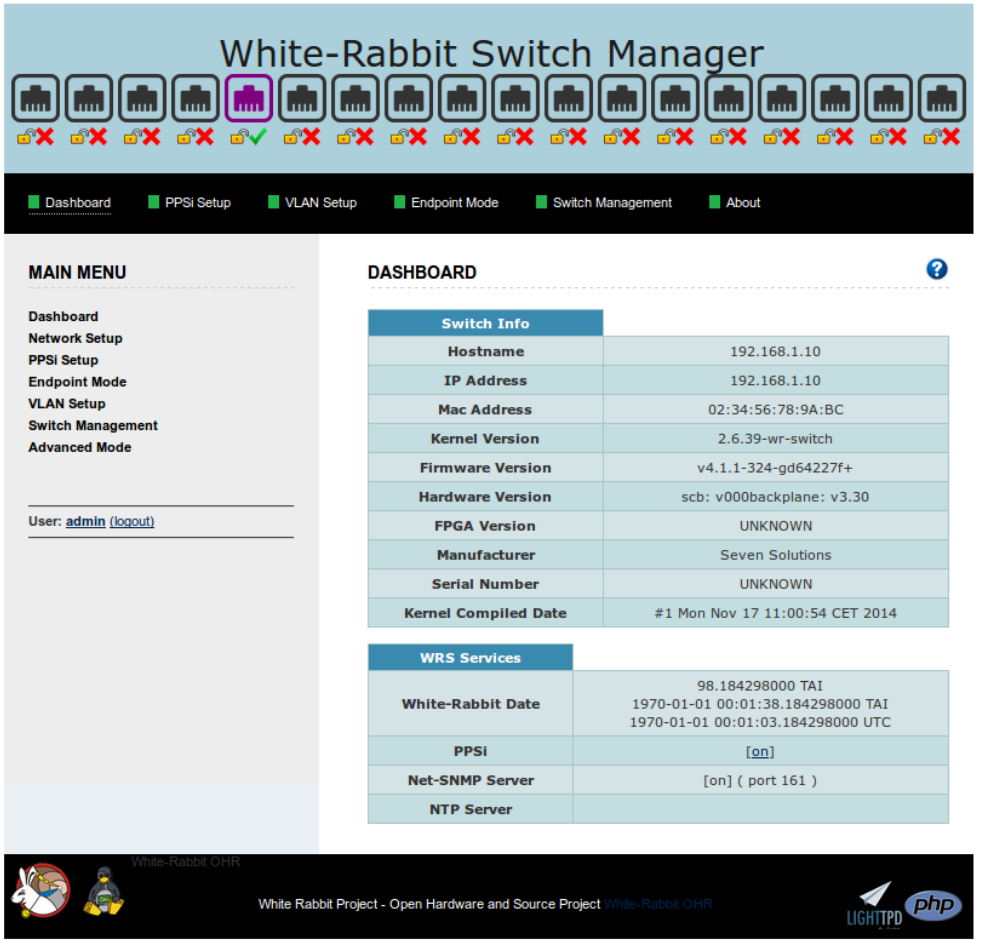
- Web interface (not recommended!)



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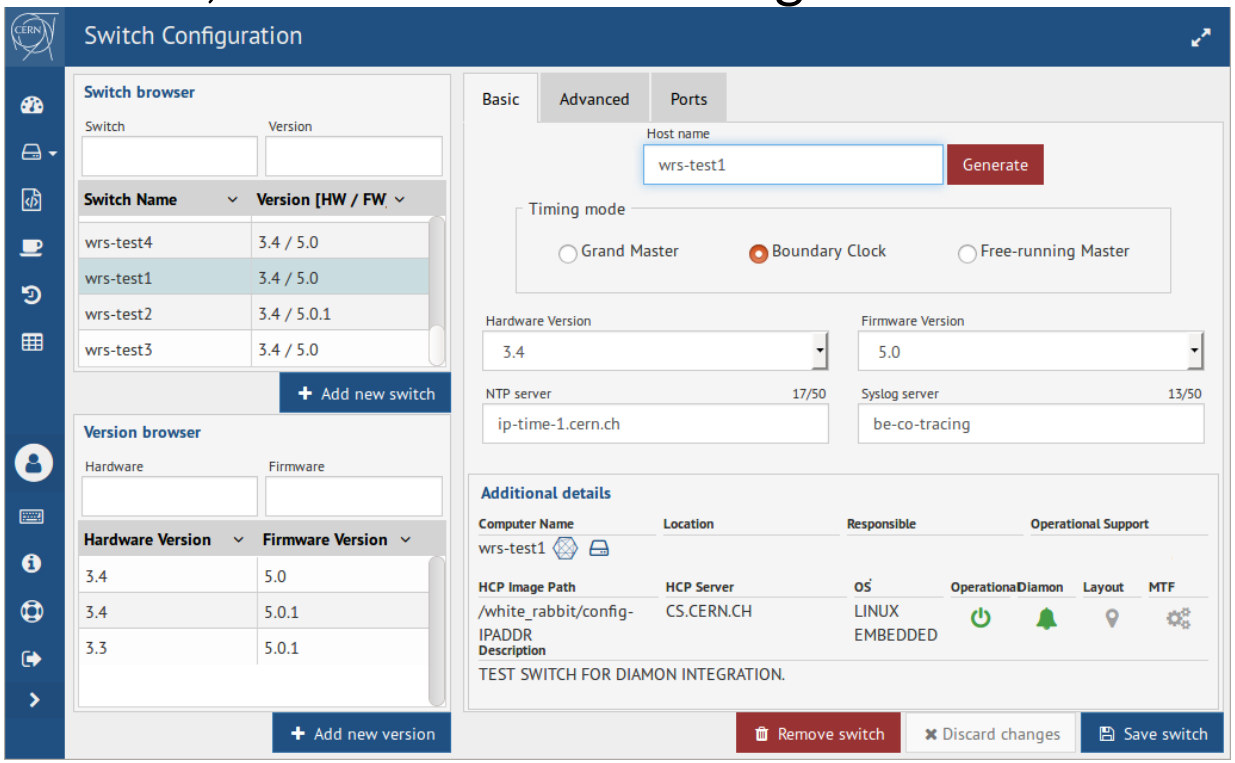
- Custom tool, CERN: Controls Configuration Data Editor (CCDE)



Step 1: Web interface for DB, it generates WR Switch config in JSON format
Step 2: Switch config is generated from JSON format by generator:
https://gitlab.cern.ch/white-rabbit/wrs-config-generator

WRS: Editing config file

- In text editor
- Kconfig tools (make menuconfig, make nconfig etc.)
- Web interface (not recommended!)
- Custom tool, CERN: Controls Configuration Data Editor (CCDE)
- Custom scripts to distribute config files (GSI)

Note: some features need to be enabled and configured in a config file to work

WRPC: Configuration

- Text file, syntax the same as WRS config
- Kconfig tools on host (make menuconfig, make nconfig etc.)
- Applied at build time
- For some features the configuration can be done by a shell command in run-time
- Startup script defined:
  - At build time
  - Run-time (saved in flash)

Note: To keep the footprint small many features are disabled by default.

WRS: other supported protocols

- VLANs (limit access between network parts)
- Syslog (logging)
- Kerberos and LDAP (authentication and authorization)

WRPC: other supported protocols

- VLANs (limit access between network parts)
- Syslog (logging), events like:
  - boot up
  - link down/up
  - sync lost
  - sync recovered
  - Temperature over threshold
- BOOTP
- Netconsole

Agenda

- A few words about myself
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- Supported protocols for monitoring and management
- **Command line tools**

WRS: wr_mon

- The best CLI tool to start with
- Gives many important information about WR Switch status and configuration:
  - Build version
    (of the tool! Not of the entire firmware.
    For the deployed firmware should not matter)
  - Link status
  - PTP/WR configuration
  - MAC of the peer (*)
  - PLL locking status
  - Timing mode
  - WR time
  - Servo status (if in slave mode)
- Similar tool exists for WRPC (gui)

```
WR Switch Sync Monitor WP3a-wrpc_fixes-23-g7f9cb63c-dirty [q = quit]

WR time (TAI)    : 2021-10-05 00:09:15.015536   Leap seconds:  37
Switch time (UTC): 2021-10-05 00:08:38.015496   TAI-UTC     : +37.000040
TimingMode: BC    PLL locking state: LOCKED
----- HAL ---|------------------------------ PPSI ---------------------------------------------
 Iface| Freq |Inst|     Name     |   Config   | MAC of peer port  |    PTP/EXT/PDETECT States    | Pro | VLANs
------+------+----+--------------+------------+-------------------+------------------------------+-----+------
 wri1 | Lock |  0 |wri1-1-wr-raw |slave       | [redacted] | SLAVE     /IDLE      /EXT_ON | V-W | 31
*wri2 |      |  1 |wri2-1-wr-raw |master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri3 |      |  2 |wri3-1-wr-raw |master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
 wri4 |      |  3 |wri4-1-wr-raw |master      | 00:00:00:00:00:00 | MASTER    /IDLE      /WA_MSG | R-W |
*wri5 |      |  4 |wri5-1-wr-raw |master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri6 |      |  5 |wri6-1-wr-raw |master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri7 |      |  6 |wri7-1-wr-raw |master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri8 |      |  7 |wri8-1-wr-raw |master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri9 |      |  8 |wri9-1-wr-raw |master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri10|      |  9 |wri10-1-wr-raw|master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri11|      | 10 |wri11-1-wr-raw|master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri12|      | 11 |wri12-1-wr-raw|master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri13|      | 12 |wri13-1-wr-raw|master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri14|      | 13 |wri14-1-wr-raw|master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri15|      | 14 |wri15-1-wr-raw|master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri16|      | 15 |wri16-1-wr-raw|master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri17|      | 16 |wri17-1-wr-raw|master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
*wri18|      | 17 |wri18-1-wr-raw|master      | 00:00:00:00:00:00 | DISABLED  /IDLE      /NONE   | R-W |
Pro - Protocol mapping: V-Ethernet over VLAN; U-UDP; R-Ethernet

-------------------------- Synchronization status ----------------------------
Servo state:          wri1:White-Rabbit: TRACK_PHASE

 +- Timing parameters ---------------------------------------------------------
 | meanDelay        :          169.628 nsec
 | delayMS          :          169.651 nsec
 | delayMM          :         1240.402 nsec
 | delayAsymmetry   :            0.023 nsec
 | delayCoefficient : +0.000267869999999987 fpa : 1235332333756144
 | ingressLatency   :          225.959 nsec
 | egressLatency    :          224.295 nsec
 | semistaticLatency:            0.000 nsec
 | offsetFromMaster :            0.002 nsec
 | Phase setpoint   :            9.851 nsec
 | Skew             :            0.000 nsec
 | Update counter   :             1371 times
 | Master PHY delays TX:          224.642 nsec  RX:          226.250 nsec
 | Slave  PHY delays TX:          224.295 nsec  RX:          225.959 nsec

-------------------------------- Temperatures --------------------------------
FPGA: 29.31 PLL: 47.69 PSL: 46.88 PSR: 48.44
```

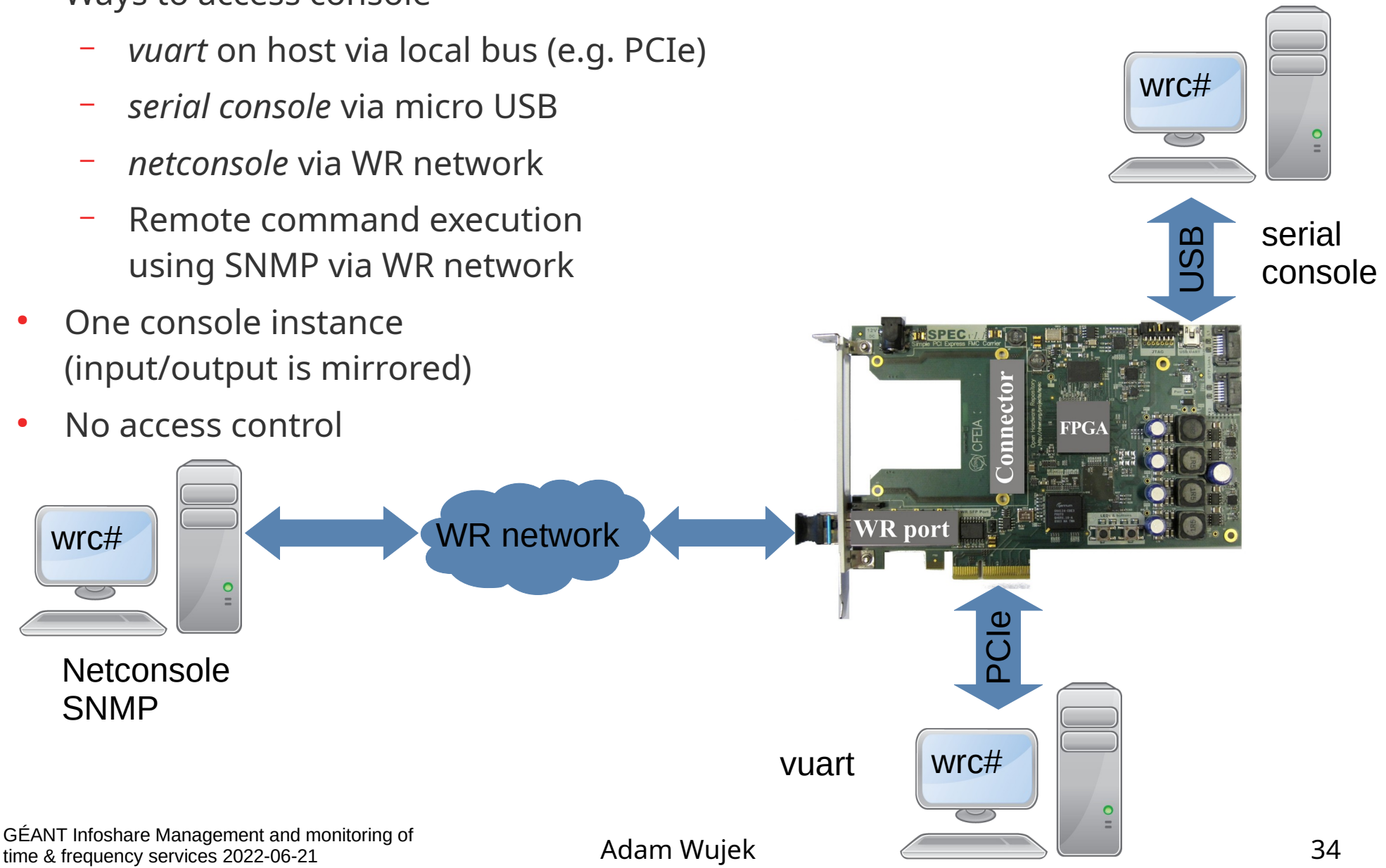
(*) - available in the next firmware release

WRS: More CLI tools

- More CLI tools available:
  - wrs_shmem_dump – display internal data structures of WR specific processes
  - rtu_stat – display switching tables
  - wrs_vlans – display vlans configuration
  - wr_pstats – detailed interface statistics
  - Number of files in /tmp – status of several subsystems
  - ptpdump, tcpdump & wireshark (with WR dissector) – PTP/WR frames analysis
  - wrs_dump.sh – remotely create dump of WRS state
- More details about these tools can be found in:
  - *WRS user manual*
  - presentation "*A quick tour through the available diagnostic and monitoring tools for White Rabbit Networks*"
    https://ohwr.org/project/white-rabbit/wikis/uploads/c5a4ca468edc2251874c3694867e12fc/tools_diagnostic_monitoring.pdf

WRPC: console

- Ways to access console
  - *vuart* on host via local bus (e.g. PCIe)
  - *serial console* via micro USB
  - *netconsole* via WR network
  - Remote command execution using SNMP via WR network
- One console instance (input/output is mirrored)
- No access control

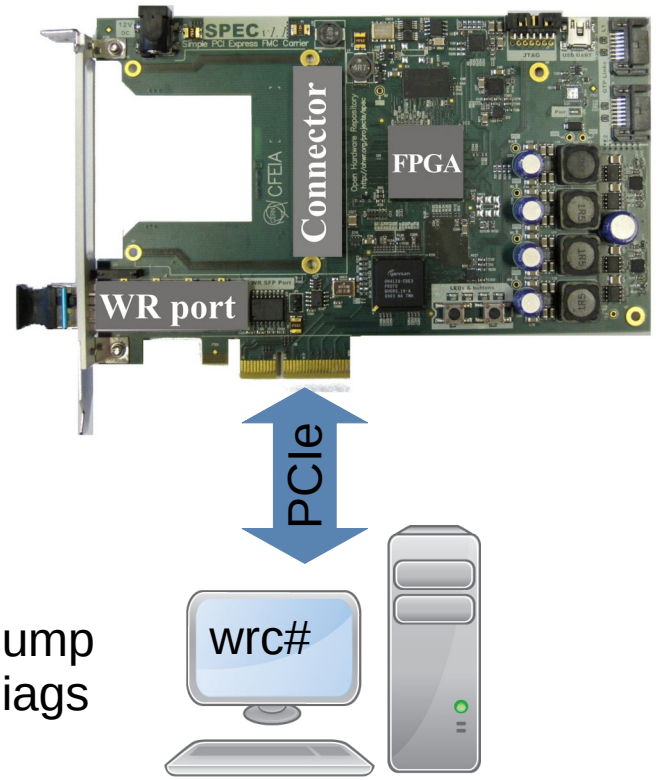


WRPC: more CLI tools

- Tools working over local bus:
  - wrpc-dump – interpret data structures in node's memory
  - wrpc-diags – display node's status (similar to gui command)

More details about these tools can be found in:

- White Rabbit PTP Core User's Manual
- presentation "A quick tour through the available diagnostic and monitoring tools for White Rabbit Networks",
  https://ohwr.org/project/white-rabbit/wikis/ uploads/c5a4ca468edc2251874c3694867e12fc/tools_diagnostic_monitoring.pdf



Thank you!

Questions?

Further reading

- Managing Your Timing System As A Standard Ethernet Network, A. Wujek, https://accelconf.web.cern.ch/icalepcs2017/papers/tush303.pdf
- A quick tour through the available diagnostic and monitoring tools for White Rabbit Networks, A. Wujek,

  https://ohwr.org/project/white-rabbit/wikis/uploads/c5a4ca468edc2251874c3694867e12fc/tools_diagnostic_monitoring.pdf